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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Piston Rings

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LUBRICATION

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Piston Rings

IN any reciprocating mechanism where liquids or gases are to be compressed or allowed to expand for the purpose of enabling them to do work, leakage past the piston must be prevented if the machine is to develop maximum efficiency. The piston ring is employed to prevent such leakage. This element is built of carefully selected cast iron. It is available in a wide variety of designs according to the service in which it is to be used, and machined to a high surface finish to assure of as complete an area of contact with the cylinder wall as possible.

The piston ring must retain its intended spring, and be capable of moving quite freely in its corresponding groove in the piston; otherwise it may fail to maintain the desired seal, and blow-by or loss of compression will result, due to sticking. This can be retarded by controlling groove clearance, producing smoother surface finishes and more uniform flatness. Other resultant benefits of surface finish are better flexibility, reduced wear on the pistons and ring faces, better sealing by the oil film, with consequent reduction in blow-by and improved heat transfer.

Research as to the cause of ring sticking became necessary with the introduction of the high compression automotive engine, the accompanying higher engine temperatures, and the increased durability which was required of engine oils. Piston ring wear had been a problem for years; barring the use of unsuitable cylinder lubricants, however, ring sticking formerly was not much of a problem. Materials and adjustment were of more concern. Wear developed when the ring pressed too tightly against the cylinder, when it had excessive spring, when cylinder surfaces were uneven, or when the lubricating film was diluted by fuel blowby, or simply reduced by heat. The use of an unsuitable oil, to begin with, was also a contributing factor.

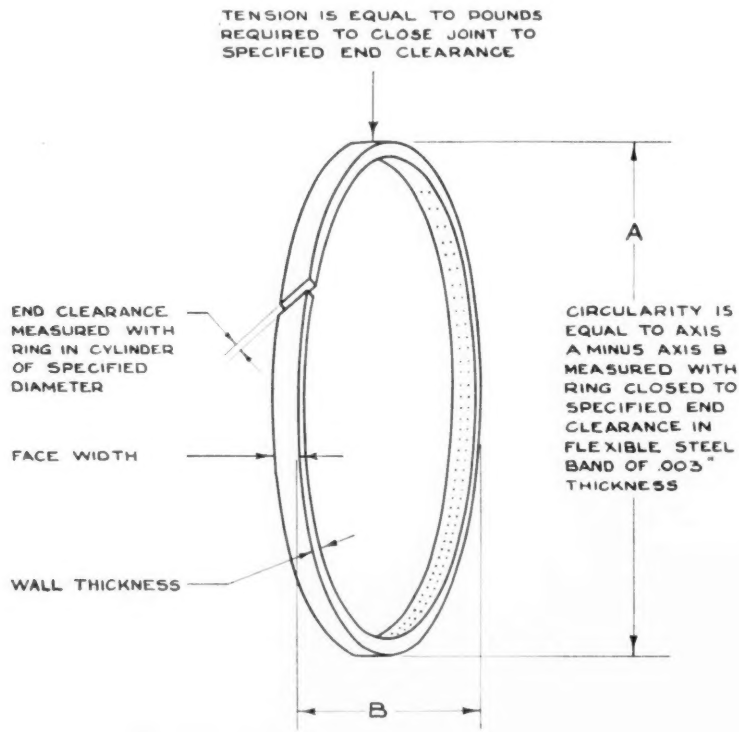
Viscosity reduction is caused by heat or dilution of a lubricating oil. The internal combustion engine and gas compressor are obviously the chief offenders with regard to dilution of cylinder lubricating oils, dealing as they do with products which are miscible in all proportions. In any type of engine, pump, or compressor, however, where a heat condition prevails, the viscosity of the cylinder lubricating oil will be reduced in proportion to the degree of heat developed.

More detailed consideration will be of interest as to the prevailing limits which exist today in modern engine or compressor operation. It is these limits, in fact, which have been so influential in bringing about study of metal structure in piston ring and liner design.

The lowest range of cylinder temperature is found in refrigerating compressor service. The piston type of pump, air compressor, steam engine, gas engine, and Diesel will show rising temperatures normally in the order named. Some variation will, of course, occur, dependent upon individual operating conditions. There will also be instances of overlapping. For this reason, study of the average temperature range in any particular installation must be made by the lubricating engineer in deciding upon the oil to use, or the piston ring authority in recommending any specific type or ring material.

The lubricating engineer gives especial con-

sideration to viscosity or relative fluidity, for the extent to which effective piston sealing can be maintained under operating temperatures will largely depend upon this property. Too thin an oil may permit blow-by to occur. Conversely, too heavy an oil may cause drag, overheating and abnormal power consumption.



PISTON RING NOMENCLATURE

Courtesy of Koppers Company, American Hammered Piston Ring Division

Fig. 1—Showing a typical piston ring with customary terms identified.

The piston ring metallurgist and designer, in turn, studies ring material, metal structure and design for the finished ring must show:

1. A dense, uniform graphite distribution.
2. A well defined pearlitic matrix, bordering on the sorbitic stage to insure adequate resistance to wear, and
3. Freedom from segregated constituents.

THEIR FUNCTION AND DESIGN

By virtue of these properties, a piston ring serves to:

1. Maintain compression.
2. Control lubrication.
3. Conduct heat away from the combustion, power or working chamber to the cylinder walls as well as the piston where the cooling system becomes effective.

Heat conductivity is most important in a heat engine of the steam, gasoline, or diesel type, or in the air compressor. In pump and refrigerating compressor service, the duty is not as severe, for heat conductivity here is less important.

When a set of piston rings is capable of performing these functions effectively, by reason of judicious design, proper installation, and intelligent application of cylinder lubricating oil, the ultimate objective—prevention of wear by preservation of an adequate lubricating film under all conditions of operation—will be more nearly attained.

In discussing the Diesel, Mr. D. D. Cook of Cooktite Ring Sales Company* is of the opinion that — "sealing rings assist materially in preventing combustion carbon from reaching the ring grooves and crosshead, or bearing, part of the piston, thus preventing sticking rings, and affording better lubrication at these points.

"There is much disagreement as to the correct location of sealing rings on the piston. Experience, however, teaches that best results are obtained if the sealing rings are located in the third and fourth, or in the fourth and fifth grooves, taking into consideration the sealing effectiveness of the style ring used, as well as the condition of the cylinder.

"The use of two oil-control rings will handle the most difficult job. While the location of oil rings remains, again, a matter of opinion, a ring in the piston skirt and a second ring above the pin, is good practice. Oil-ring grooves in all cases should be deeper than compression-ring grooves to facilitate return of the oil to its source."

Compression Loss and Blow-by

Loss of compression is synonymous with blow-by. When it occurs, the hot gases from the combustion or power chamber pass the rings to destroy the protecting oil film and

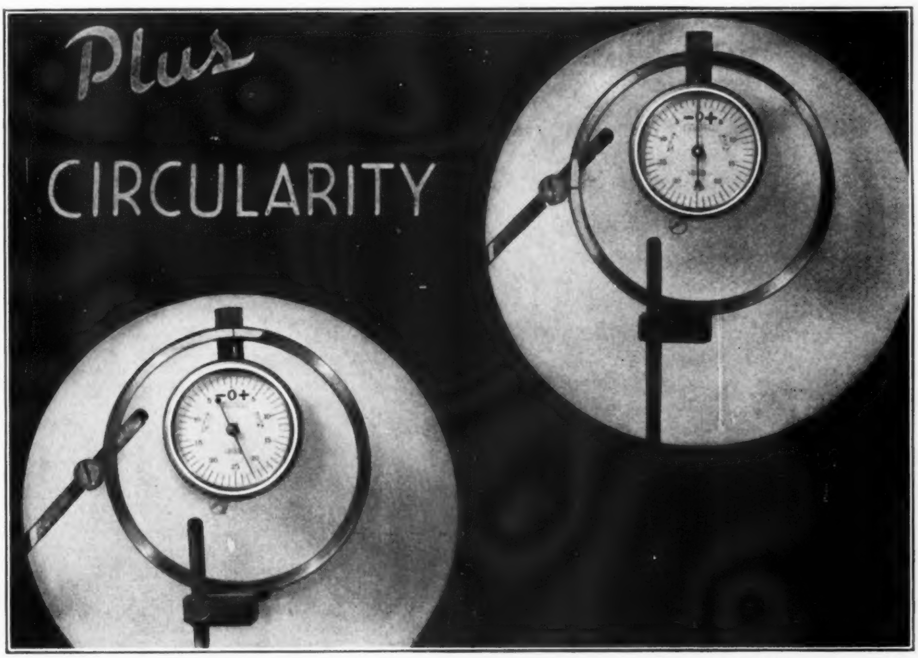
* From paper presented at the Twelfth National Oil and Gas Power Meeting of the A.S.M.E., at Ann Arbor, Michigan, June 19–22, 1939.

permit metal-to-metal contact of rings and cylinder, resulting in excessive friction, heat and wear.

According to Mr. J. M. Dodge of the Double Seal Ring Co., Inc., *—"the important effect of high temperatures on cast iron is a very interesting one. In the Diesel, under normal conditions, the resulting piston-ring temperature will be from 300 to 500 degrees Fahr. Cast iron, when subjected to long-continued temperatures of 500 degrees or more, tends to separate out graphite. This causes an expansion of the piston ring, which in time will deform and ruin it.

"On the other hand, failure of lubrication in the region of the top piston ring, resulting in metal-to-metal contact, will raise the temperature of the ring to a red heat, or about 1400 degrees Fahr. Near this temperature pearlitic iron breaks down into ferrite, or pure iron, which is soft, and has a decreased tensile strength. These critical temperatures are among the contributing causes of piston, liner and ring wear."

The plain snap ring is regarded as most conducive to blow-by, although this occurrence is also influenced by piston speed, according to Messrs. Paul Lane and John Worthington of The Koppers Company, American Hammered Piston Ring Division, who state that—"engines with a piston speed of approximately 1000 feet per minute are not subject to appreciable leakage or blow-by through the joint. On the higher speed engines blow-by usually occurs on the outside diameter of the ring adjacent to the joint. This condition is greatly exaggerated in high speed automotive engines, and can be corrected by giving additional support to the weak section of the ring near the joint. This is generally accomplished by manufacturing the rings with plus circularity. In other words, when a ring is measured at various points around its circumference while held in a flexible band of cylinder size, it is said to have plus circularity if the axis through the joint is greater than the axis 90 degrees from the joint. Rings with plus circularity will have greater pressure at the joints than rings with zero circularity or minus circularity. This additional strength at the weakest section of the rings is essential in all high speed engines, and the greater the piston speed, the greater the plus circularity required. On the other hand, regardless of the amount of plus circularity that a ring has when placed in a flexible band, it must, of course, conform perfectly to a true cylinder when confined in the cylinder."



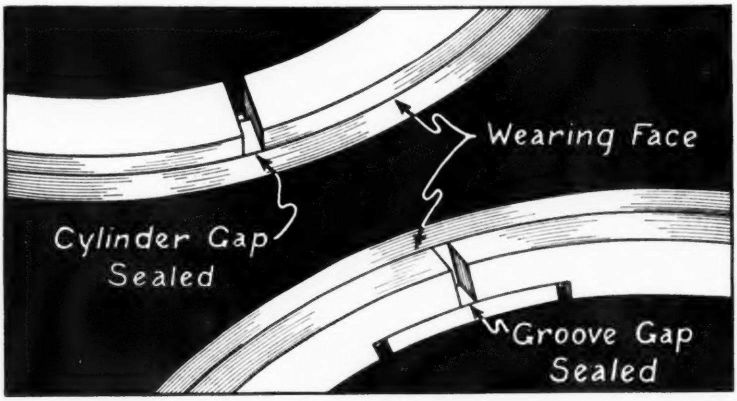
Courtesy of Sealed Power Corporation

Fig. 2—Showing method of determining plus circularity.

The possibility of leakage through the ring joint will vary inversely with the piston speed,

* From paper presented at the Twelfth National Oil and Gas Power Meeting of the A.S.M.E., at Ann Arbor, Michigan, June 19–22, 1939.

i.e., the lower the latter, the greater the probable leakage. This leakage may destroy the oil film at the start, causing wear at the point of passage. Several types of single-piece piston rings with special joints as well as numerous designs of multiple-piece rings, are manufactured which develop excellent joint seals. The same authorities go on to state that "seal rings, while of questionable value in new engines, are frequently essential in badly-worn cylinders. For example, consider a 20-inch ring in a cylinder having a taper of 0.100 inch. If this ring has the normal gap clearance of 0.100 inch at the smallest part of the cylinder, it will have a gap clearance of 0.100 inch, plus 3.14 times 0.100 inch, plus 3.14 times 0.100 inch, or a total of 0.414 inch, at the largest part of the cylinder. Under such conditions, which are not unusual, a seal ring is obviously desirable.



Courtesy of C. Lee Cook Manufacturing Company

Fig. 3—How the Cooktite sealing ring functions in compensating for excessive gap clearance.

"In addition to the requirements that it must be perfectly round in the cylinder with the proper radial pressure at all points, a ring also must be perfectly flat so that a seal is assured against the lands of the groove. By suitably providing for these factors in the manufacture of the rings, blow-by can be reduced to the minimum."

Maintaining the Oil Film

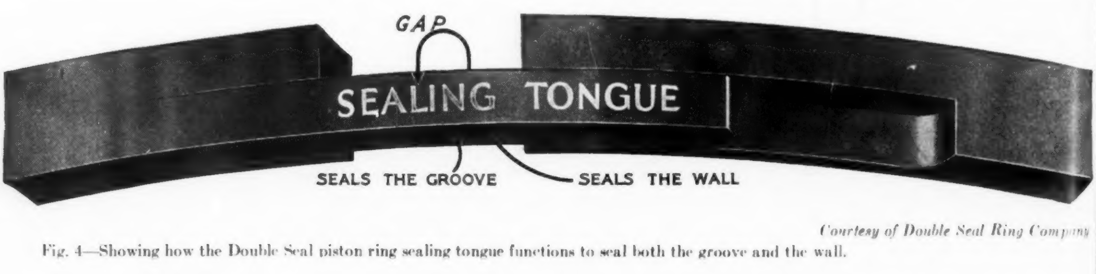
Uniform distribution of oil over the cylinder walls is maintained by the piston rings. This function is intimately related to prevention of oil pumping and blow-by due to the detrimental effect which the latter (especially) will have upon the oil film on the cylinder walls on the working stroke. The tension in the compression or power rings, therefore, must be sufficient to press the oil film tightly and evenly against the cylinder wall. It must also be uniform over the entire contact surface of the rings, for any unevenness may lead to so-called "high spots" in the film and develop oil pumping or passage of an excess of lubricating oil past the rings into the compression or top side of the engine or compressor. There is, of course, difference of opinion as to just what ring tension should be, also the relative advantages of wide versus narrow rings.

In this connection Lane and Worthington state that:

"A light tension ring rides up on the oil, leaving a very light tension film. On the working stroke, a weak film of oil is easily blown out of the space between the ring and cylinder so that the ring rubs against the cylinder, unprotected by oil, thus starting wear. On the other hand, an oil film which is pressed firmly by a piston ring will have sufficient tension in itself to resist blow-by, thus forming a perfect seal and preventing wear.

"The oil control ring must have sufficient unit pressure in order to remove excessive oil from the cylinder wall. This pressure can be twice that of a compression ring without danger, as the oil ring is away from gas pressure and well lubricated. This high unit pressure can be secured by cutting down the cylinder contacting surface so as to reduce the bearing area, as on bevelled and grooved rings.

"A slotted ring also has a greatly reduced



Courtesy of Double Seal Ring Company

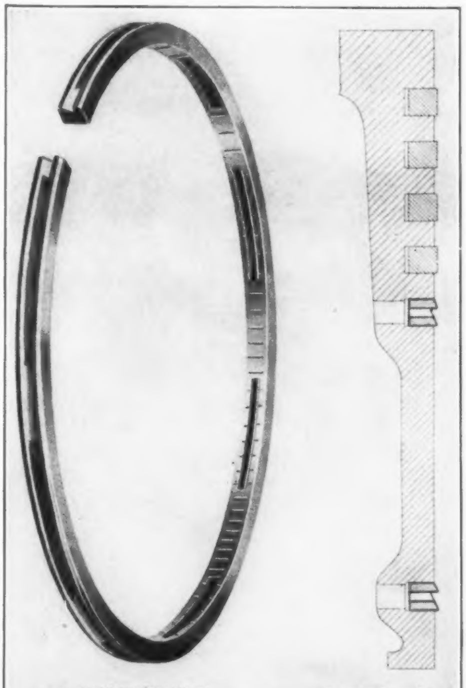
Fig. 4—Showing how the Double Seal piston ring sealing tongue functions to seal both the groove and the wall.

GOLD SEAL PISTON RING — Typical Installation

Courtesy of Koppers Company, American Hammered Piston Ring Division
Fig. 5—(a) The American Hammered Gold Seal Piston Ring;

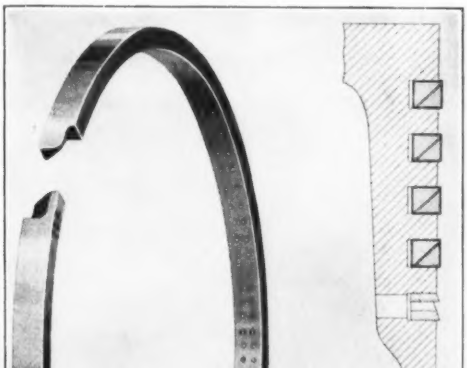
bearing area and correspondingly increased unit pressure. The operation of the slotted ring may be described as follows: As the advancing edge of the ring passes over the film of oil on the cylinder, it exerts a heavy pressure which is suddenly relieved over the area of the slots. The oil then rushes into the slots in the same way that water rushes in behind a moving ship. The following edge of the ring keeps the oil in the slots and guides it towards the drain holes in the back of the piston groove.

"The unit pressure of rings can be increased by the use of expanders. When these are provided with oil vents, they may be used effectively in conjunction with slotted oil rings.



OILCUTTER RING — Typical Installation

(b) The American Hammered oil cutter ring;



STEP SEAL RING — Typical Installation

(c) The American Hammered Step Seal Ring.

"When slotted rings are used, as is customary on four-cycle internal combustion engines, it is necessary to have drain holes drilled in the back of the piston grooves. Ample area of drainage must be provided both in the slots in the rings and in the holes in the piston because insufficient area will retard the quick passage of excess oil and cause the holes and slots to clog up. When the pistons are not drilled or when all of the drilling is below the ring grooves, bevelled rings are used as oil scrapers."

Mr. Stuart Nixon of Sealed Power Corporation* adds that "in mathematical analysis, the

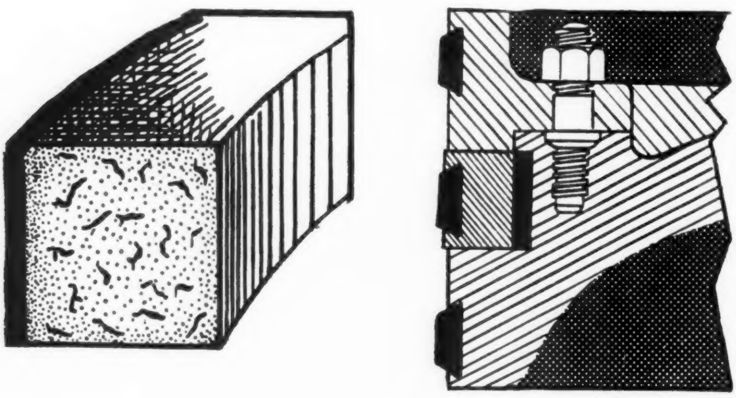
*From paper presented at the Twelfth National Oil and Gas Power Meeting of the A.S.M.E., held at Ann Arbor, Michigan, June 19-22, 1939.

ring of rectangular cross-section can be treated either as a cantilever beam, or as a curved beam. In either case, the tension is proportional to the free opening, and inversely proportional to the ratio of the diameter to the thickness cubed. The stress in the ring is a maximum at the back of the ring, and proportional to the ratio of the diameter to thickness squared.

"The free opening is limited by the amount that a ring has to be opened to install it, and the amount it has to be compressed in its working position. In either case, the ring should not be overstressed. So, since the maximum thickness for the initial condition is limited by the safe generating stress, the designer has to consider the thickness of the ring, the free opening, and the relation to the stresses in the ring for his particular application."

Courtesy of Sealed Power Corporation

Fig. 6—Showing in contrast the Sealed Power design of compression ring and Super Drainoil ring.



Courtesy of C. Lee Cook Manufacturing Company

Fig. 7—Showing the Cook method of "tinizing" a ring surface, or locating anti-friction metal inserts, in order to increase ring life and reduce cylinder wear.

Depth of the Ring Grooves

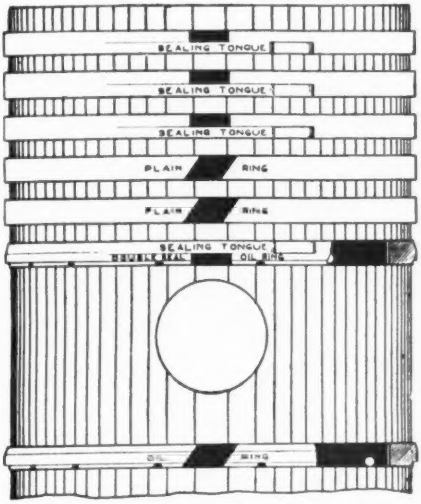
Inasmuch as one of the principal functions of a piston ring is to transfer heat, the radial or wall thickness of the rings and corresponding depth of the grooves in the piston are of distinct importance. In the opinion of certain authorities, this has been too frequently overlooked, with the result that many pistons in the past have been designed with grooves entirely too shallow. Some suggest a radial ring depth of approximately 0.040 inch per inch of diameter, although a variation of from 0.050 inch for rings of 1.0 inch diameter to 0.030 inch for rings of 2.0 to 50.0 inches diameter is permissible. This is about the maximum that can safely be sprung over a solid piston.

In addition to insufficient heat transfer, other detriments which may result from too shallow ring grooves will include sticking of rings, accumulation of carbon, blow-by, abnormal groove wear, and sometimes distortion of the ring itself. This latter may occur where an attempt is made to use a deeper ring than the grooves are designed for. Some authorities feel that depth of ring grooves in pistons is directly related to the amount of blow-by, the one becoming, therefore, a measure of the other to some extent.

HOW FUEL COMBUSTION AFFECTS RING PERFORMANCE

The performance of piston rings and their relation to cylinder liner wear in Diesel service should commence with the fuel. Considerable wear will result if this latter contains any appreciable amount of abrasive, foreign matter. Wear also may be affected by improper combustion.

In addition to wear, a fuel of comparatively high foreign matter content may cause the piston rings to stick and the valves to function imperfectly, due to accumulation of such matter around the valve stems.



Courtesy of Double Seal Ring Company

Fig. 8—An application of Double Seal rings on a seven groove piston of a four-cycle oil or gas engine. Note holes drilled back of oil rings to enable drainage and reduce lubricating oil consumption.

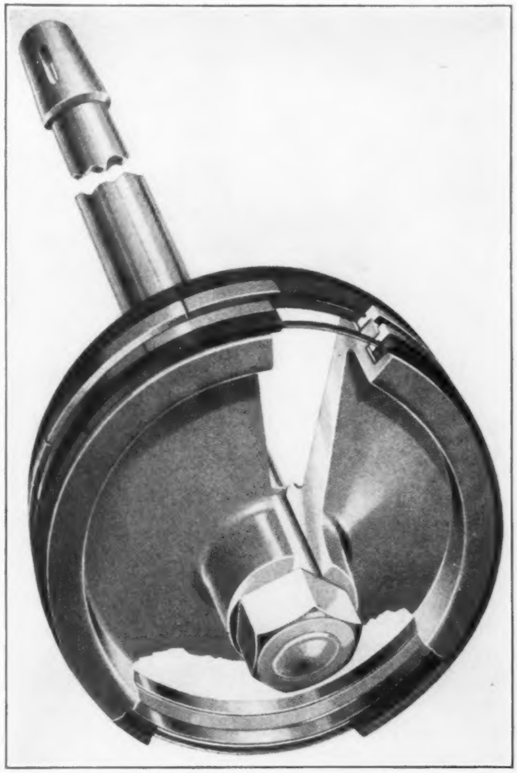
Careful study should be given, therefore, to the fuel analysis and to installation of suitable equipment for purification prior to usage. It is practicable to remove virtually all suspended solid or non-combustible matter from the average Diesel fuel with the centrifugal purifier. Unfortunately, sulfates developed as products of combustion in high sulfur-content oils remain to sometimes become detrimental in contributing to liner wear, especially where they may have united with iron to increase their abrasive nature. Combined with carbonaceous residue from either the fuel or lubricating oil, such sulfates of iron are one of the causes of stuck rings. The sulfur content should, therefore, never be overlooked, especially since it introduces the added possibility of development of corrosion due to acid formations in the presence of moisture, particularly on standby.

Incomplete Combustion

Whatever the cause of improper combustion, the result will be that all of the fuel supplied to the combustion chamber is not completely burned. Where this occurs, the unburned portions of the atomized fuel will to some extent be caught by the oil film on the cylinder walls, or else tend to creep past the piston rings, eventually to reach the crankcase in the trunk type engine. Both will affect the quality of the oil film; in the first case, by changing the viscosity due to the content of solid matter; in the second case, by rendering it abrasive.

Fuel Quality a Factor

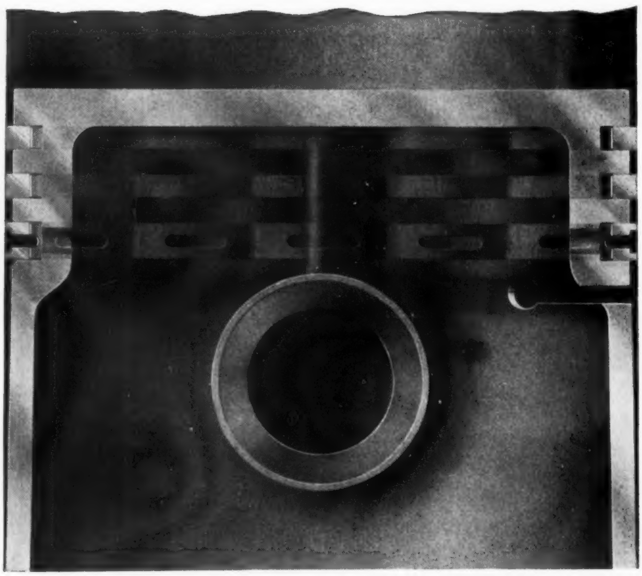
Non-combustible mineral matter dissolved or suspended in the fuel is an active cause of wear. Its presence is indicated by the ash content when the fuel is subjected to laboratory test. Unless effective fuel oil filters are used, a considerable portion of this mineral matter will exist in the form of an extremely fine powder after combustion, some being swept out and carried along by the exhaust gases. Some, however, will be caught by the lubricating oil film, thus impairing lubrication and increasing wear. But however serious wear may be, due to excessive ash content, the latter cannot be held responsible for the fact



Courtesy of Koppers Company, American Hammered Piston Ring Division

Fig. 9—An installation of American sectional bronze-iron packing in locomotive main cylinder service. This combination aids in extending the life of all attendant parts, reducing friction and wear.

that cylinder liners do not wear uniformly, but instead show maximum wear very near the top of the stroke, to ultimately become barrel-shaped.



Courtesy of Sealed Power Corporation

Fig. 10—A piston equipped with Sealed Power "Sta-tite" rings.

RELATION OF LUBRICATION SEAL TO CYLINDER WEAR

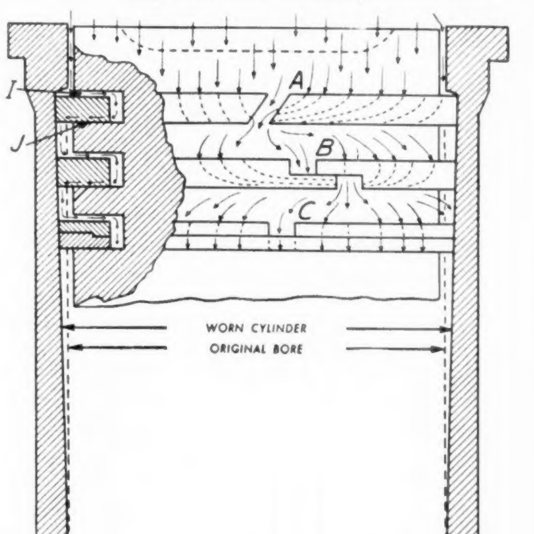
Research has indicated that the zone of maximum wear will develop where maximum pressure and temperature exist in the cylinder and where the piston speed is lowest. The exact reason for this is not quite understood, but it seems reasonable to expect that more wear will occur where the metal is regularly heated and pressure-stressed than where stresses are less severe.

Certain authorities feel that for a given cylinder size, wear and revolutions per minute may be related. Others regard increased piston speed as tending toward a more even distribution of wear.

To quote D. D. Cook*—"the rate of cylinder wear for any particular engine is peculiar to the engine under observation, and is obtained only by keeping a careful log of cylinder calculations over a period of time. While one per cent wear (per thousand hours of operation in Diesel service) is a constant used quite generally, the size of the engine and other conditions may require liner replacement at 0.5 per cent wear.

"Eliminating from the discussion automotive-size equipment, and wear, resulting from abnormal operating conditions, it is not unusual to find cylinder wear as low as 0.0005 inches, and as high as 0.009 inches per 1000 hours of operation, in modern engines running under efficient direction. In the former case, the engine is usually found to be of moderate cylinder bore, carrying a light load and with all other factors favorable, while in the latter class, the engines are usually found to be of the larger size, fully loaded, using a poor grade of fuel or handicapped by some other wear factor, such as frequent starting and stopping, over which the operator has no control.

"Cylinder wear can be reduced materially by paying attention to the piston ring functions, and to the materials of which the rings are made. In particular, rings which make possible improved lubrication by eliminating flame impingement and by preventing the products of combustion from impairing the oil film, are contributing much to increasing cylinder life and to reducing the cost of the cylinder wear."

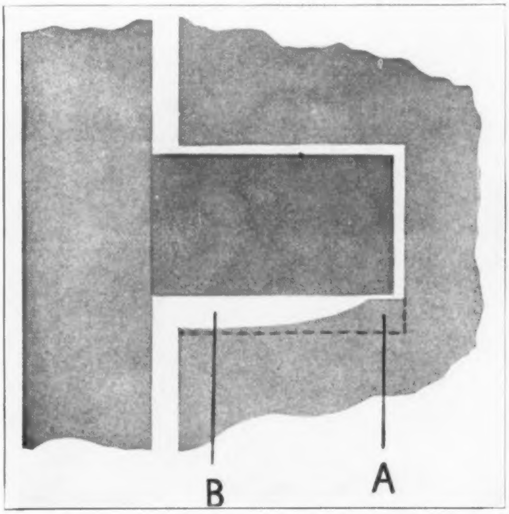


Courtesy of C. Lee Cook Manufacturing Company

Fig. 11—Showing piston ring function in worn and unworn parts of a cylinder. Joints of rings A and B have excessive clearance when in worn area, and permit leakage as arrows indicate. Ring C is a sealing ring to prevent leakage due to excessive gap clearance. All these rings fit snugly in the unworn area.

* From paper presented at the Twelfth National Oil and Gas Power Meeting of the A.S.M.E., held at Ann Arbor, Michigan, June 19–22, 1939.

It is obvious that piston rings must bear evenly over their entire surface of contact with the cylinder walls if effective lubrication and seal are to be maintained. To insure even bearing, the rings must fit evenly in their grooves, and yet be capable of free movement or floating. For this reason, it is highly essential that the grooves be accurately machined and absolutely parallel. Proper fitting will also insure even bearing on the sides of the grooves, which will afford a further advantage in preventing accumulations of carbon and leakage of steam, air, refrigerant, or gases of combustion back of the rings, to cause loss of compression. Maintenance of compression therefore, should be indication of not only suitable ring installation, but also effective lubrication. Accumulation of gases in back of the rings may cause localized overheating, formation of carbonaceous residues, stuck rings, and uneven wear.



Courtesy of Double Seal Ring Company

Fig. 12—Showing a new ring in a stepped or worn groove. Such shoulders (see A) are undesirable. They should be corrected as they promote continued leakage.

The type of ring should always be studied in connection with this matter of ring fit and installation, for with certain designs it is possible to install them upside-down, a procedure which would lead to abnormal oil consumption, impairment of the seal and loss of compression.

Freedom of motion is also very essential. Obviously, it cannot be assured even with the best of lubrication, if the rings bind mechanically. The utmost care should be given, therefore, to the clearance space between the ends of the rings. Too slight clearances may lead to excessive liner wear, for obviously if a ring cannot expand freely without actual contact of its butt ends, it will drag over the liner, even breaking in certain cases due to the vibrations developed, particularly on the explosion or expansion strokes in the internal combustion engine.

RING CLEARANCE

This must be considered from two points: end clearance and side clearance. The former should be measured when the ring is fully compressed, in accordance with the probable expansion of the ring material under the maximum temperatures which may prevail.

Clearance—either side or end—must be carefully considered in any internal combustion engine. Too much clearance may lead to accumulation of heavy fuel residues, back of the top rings, particularly where the gases of combustion are able to work their way more or less freely around the rings. This will lead to stuck rings quite as readily as carbon accumulations from excessive use of unsuitable lubricating oil.

Courtesy of Koppers Company, American Hammered Piston Ring Division

Fig. 13—Details of American Hammered ventilated inner rings, which can be placed in piston grooves behind slotted oil rings in high speed internal combustion engines, to aid the oil rings in removing excess oil from the cylinders.

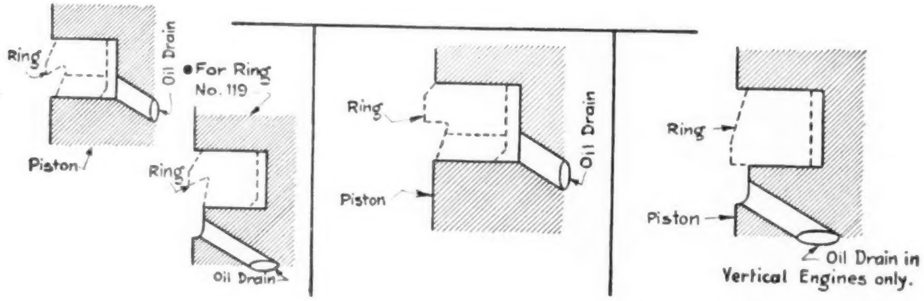
How Blow-by Occurs

Blow-by can be very often traced to excessive lubrication and carbon formation around the rings, particularly in worn cylinders, the lubricant seal being subsequently destroyed by leakage of gases under pressure past the rings. Such formations will reduce free motion of the rings and ultimately cause them to stick, particularly where engine or compressor operations give rise to higher temperatures. In the air compressor, or refrigerating unit, the working temperatures are lowest, increasing where steam is involved, and becoming highest in the Diesel, or ignition type of internal combustion engine. These temperatures range from an average of perhaps 250 degrees Fahr., for air, to 500 degrees Fahr., for normal pressure superheated steam. In the Diesel engine, however, they may range up to the neighborhood of 2800 degrees Fahr. Obviously, if gases of even 200 to 300 degrees Fahr., temperature were to blow past the piston rings relatively unretarded, they would very soon cause abnormal vaporization of the lighter or more volatile fractions contained in the lubricating oil, to result in accumulation of heavy residues around the rings. The higher the temperature of the gases, the more rapidly this takes place.

This should not be charged against the lubricating ability of the oil, for any petroleum product will vaporize, although the extent to which residual formations may result when the oil is subjected to sufficiently high temperatures will depend upon the base.

Once free motion is impaired, more or less blow-by can be expected, regardless of the type of engine or compressor. As this continues, liner wear will often develop adjacent to the cylinder heads, particularly in the internal combustion type of engine.

Free motion of the rings can be aided by controlled lubrication, provided the oil used is properly refined to a sufficiently low carbon residue content. Control of lubrication is most readily attained by use of a mechanical force-feed lubricator in the average steam engine, air compressor, or the larger type of Diesel or gas engine. In smaller trunk-piston type internal combustion engines, however, cylinder lubrication is maintained by splash.

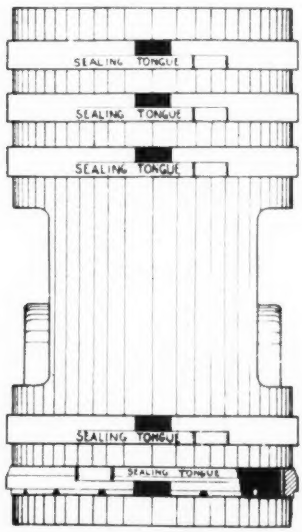


Courtesy of C. Lee Cook Manufacturing Company

Fig. 14—Groove drilling for oil draining is effective (as above) to reduce oil waste and permit wiper and scraper rings to function more effectively.

THE BENEFIT OF LOW CARBON RESIDUE

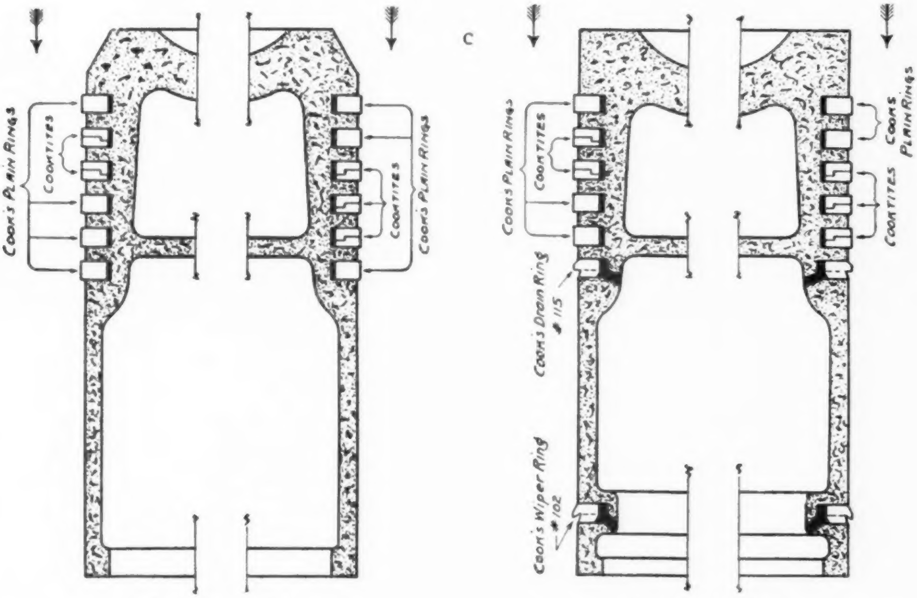
The value of low Conradson carbon residue in lubricating oils, especially in air compressor and internal combustion engine service, should never be overlooked. Actual experience has indicated that using an oil of less than 0.1 per cent carbon residue, fouling of rings will be



Courtesy of Double Seal Ring Company

Fig. 15—An application of Double Seal rings to the five-groove piston of a single-acting ammonia compressor.

materially reduced with resultant maintenance of compression and remarkably low oil consumption. In one particular high speed test which was run to approximate service conditions for 700 hours, no appreciable loss of compression was shown, make-up was less than 2 per cent of the total amount of oil charged, and analysis of the used oil indicated that wear was virtually negligible.



2-cycle Engine Piston

4-cycle Engine Piston

Courtesy of C. Lee Cook Manufacturing Company

Fig. 16—How Cook rings (according to type) are located on a two-cycle and four-cycle engine piston.

RING PRESSURE

The extent to which pressure is developed by penetration of air, refrigerant gas, steam, or gases of combustion back of certain types of piston rings, should be regarded as contributing cause of abnormal liner wear, is open to discussion. Obviously within a restricted chamber exposed to pressure such as is formed by the cylinder head and that portion of the cylinder wherein expansion or compression takes place, there will be a tendency toward equalization of pressure. In other words, while the pressure prevailing above and around the piston will in many cases also find its way to the annular spaces in back of at least the uppermost piston rings, the outward force exerted in back of these rings will largely be offset by a force of equal intensity working against the exposed parts of the rings.

Gas Pressure vs. Ring Tension

It is important to differentiate between the relative effects of ring tension and gas pressure upon liner wear. The former is essential in the interest of reducing blow-by and maintaining a suitable seal; the latter is inherent to operation. Average industrial practice where large rings are involved, employs rings which will exert pressure of from 6 to 10 pounds per square inch of contact surface. Normally this will not be sufficient to cause extensive wear, unless lubrication is seriously impaired. An adequate seal in company with effective lubrication will materially prevent blow-by and the wear-producing effects of gas pressure past the rings, especially when these latter are capable of flexible action in comparatively clean, parallel piston grooves.

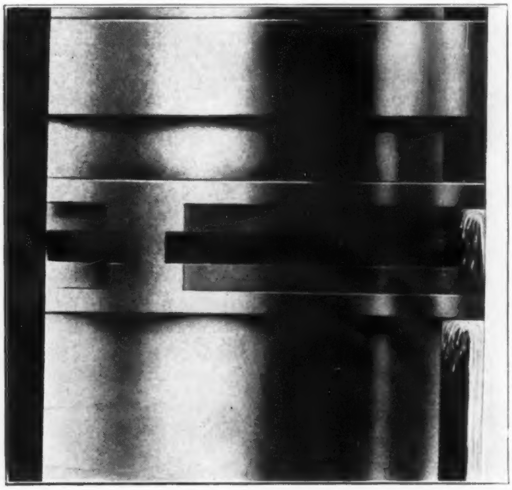
Wear as it results from gas pressure is a function of velocity, being actually a form of erosion. Consequently, the higher the pressure to which the piston may be exposed upon its expansion or compression strokes, according to the type of engine or compressor, the greater the potential velocity of the gas at the point of leakage, hence the greater the resultant wear. It is minimized in the high speed Diesel, especially, by improved methods of cooling and the use of positive means of lubrication.

LINER MATERIAL

Alloy cast iron liners are claimed to be conducive to elasticity and resistance to temperature stresses, so the possibility of cracked liners is reduced.

According to certain foreign authorities,

study of liner cracks in Diesel service over a period of several years has indicated marked similarity in occurrence. These have been observed to start at the upper edge of the inside bore of the liner, extending downward and



Courtesy of Sealed Power Corporation
Fig. 17—Showing how Sealed Power provides sealing to prevent abnormal oil pumping past the rings. Oil diversion is clearly indicated.

outward until they reached the outside, when water leakage occurred. It is reasonable to presume that such cracks are caused by temperature stresses, aided by lack of adequate cooling in liners of conventional design.

The use of vanadium, chromium and nickel alloy constituents, where thorough and even distribution throughout the casting is brought about, has been found to increase strength and resistance to wear with encouraging maintenance of compression and economy of lubricating oil.

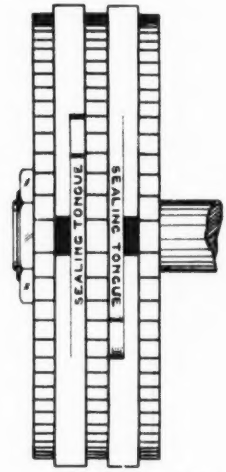
RING STRUCTURE

A variety of opinions have been held regarding the relative hardness which should prevail between piston rings and cylinder liners, especially in internal combustion engine service. Some have felt that rings should be softer than liners in order to protect the latter, and employ the more easily replaceable piston rings as the wearing elements. Others, in turn, have held to the opposite thought, feeling that by using rings harder than their liners they would develop a more uniform balance of wear in conformation with the areas involved.

It has most recently been brought out, however, that hardness could better be regarded as secondary to the actual structure of the materials involved. Piston ring iron is controlled as to structure and hardness by the size and manner of handling in the process of manufacture. In softer iron, a larger percentage of the total carbon is in the primary graphitic state. In harder rings, on the other hand, there is less primary graphite and more combined carbon. It is this metallic or grain structure which today is regarded as having more of an effect upon liner wear than the relative hardness of the respective materials. In any event, the element that causes scoring should be eliminated, thus insuring longer ring and liner life especially should lubrication become reduced.

IN CONCLUSION

The plant lubricating engineer can become a factor in the maintenance of efficient engine, compressor and pump service, by study of piston ring design, function and installation. In this he will receive the utmost cooperation from ring manufacturers. By developing a better knowledge of the types of rings available for the specific operating conditions which prevail in his plant he can also improve his value



Courtesy of Double Seal Ring Company
Fig. 18—How Double Seal rings are set in a two-groove piston of a double acting pump, compressor, or engine.

to the latter by advising when purchases are to be made. Incidentally better knowledge of piston rings leads to improved cylinder lubrication; both, in turn, should reduce maintenance costs.

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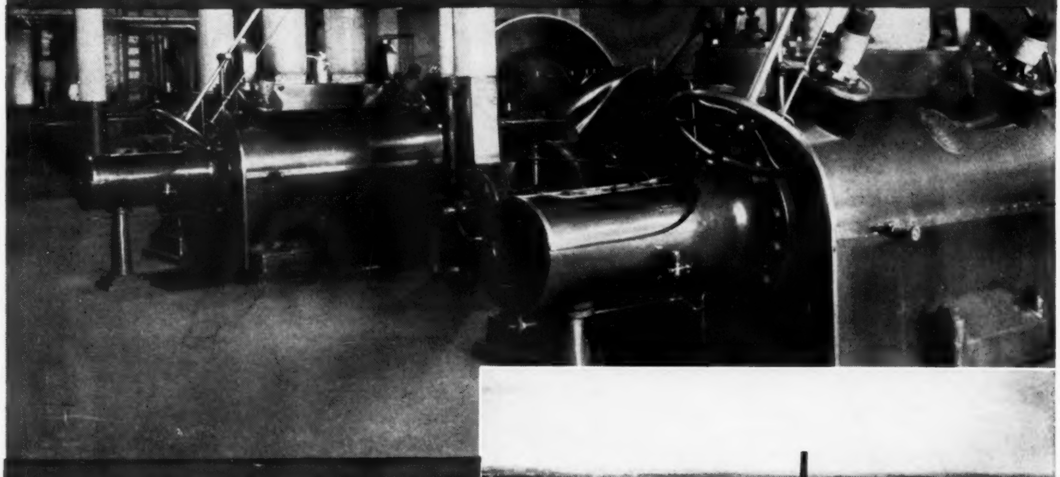

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